e. Remove all shipping stops, blocks, straps, hold-down bolts and packing from the pump and drive motors, pressure gages, relays, motor starters and instruments.

f. Complete the facility air, oil and water hookups described in the above paragraphs (refer to figure 2.1).

2.2.3.1. Electrical Connections. Facility power for the test stand is routed into the electrical enclosure thru the roof panel. Connections are at L1, L2 and L3 on the main power circuit breaker (720).

WARNING

Before connecting wires to their respective terminals, check continuity and grounds. After the wires are connected, double-check proper routing with an ohmmeter. Ensure facility power disconnects are open before connecting 460-volt circuits.

Interconnecting wires and conduit have been disconnected and supplied with the test stand. Refer to figure 2.1 to make the necessary connections between the facility, the test stand and the drive units.

2.3. TEST STAND SETUP.

Set the following test stand interior controls as indicated:

a. Ball valve (116) air gun supply, open
b. Ball valve (122) shop air supply, open
c. Ball valve (123) reservoir drain, closed
d. Ball valve (138) oil supply, pump (340), open
e. Ball valve (141) reservoir fill, open
f. Ball valve (147) oil supply, pump (341), open
g. Ball valve (148) water supply, open
h. Air pressure regulator (400), to 50 psig
i. Air pressure regulator (401), to 90 psig
j. Air pressure regulator (402), to 20 psig
k. Ball valve (146), air tank (501) drain, closed
l. Ball valve (142), air tank (316) drain, closed

m. Temperature controllers (552), to 100 °F

n. Temperature controllers (553), to 100 °F

o. Temperature controllers (554), to 100 °F

p. Circuit breaker (720), to on/closed

q. Circuit breaker (721), to on/closed

r. Circuit breaker (723), to on/closed

s. Circuit breaker (724), to on/closed

t. Circuit breaker (700) (drive cabinet), to on/closed

2.4. FLUSHING PROCEDURES.

All air and liquid lines, the oil reservoir and collection tank have been purged and sealed at the factory and should be ready for operation when received. However, the test stand oil system and the units being tested are very sensitive to contaminants. Therefore, the required oil sampling and inspection procedures must be observed to ensure system contamination limits are not exceeded.

2.4.1. OIL INSPECTION. Oil inspection may be performed with an automatic oil particle counter, Pacific Scientific Co. model 4100 or equivalent, or as outlined below.

WARNING

Lubricating Oil MIL-L 23699 or MIL-L-7808

- If oil is decomposed by heating, toxic gases are released.
- Prolonged contact with liquid or mist can cause dermatitis and irritation.
- If there is any prolonged contact with skin, wash area with soap and water. If solution contacts eyes, flush eyes with water immediately. Remove saturated clothing.
- If oil is swallowed, do not try to vomit. Get immediate medical attention.
- When handling liquid, wear rubber gloves. If prolonged contact with mist is likely, wear approved respirator.

a. Using a clean container, drain off 100 milliliters of oil.

b. Shake container to keep contaminants evenly dispersed.

c. Flush collected oil thru a 5.0-micron Millipore filter, or equivalent.

d. Using procedures outlined in Aeronautical Recommended Practice Bulletin 598 (ARP 598), determine number of particles on filter.

e. Particle counts in excess of those listed below constitute system contamination.

Particle size (microns)	Particle count (maximum)
10 to 25	2680
25 to 50	380
50 to 100	56
100 and over	5

2.4.2. FLUSHING REQUIREMENTS. Test stand low pressure circuits which become contaminated will require 3 to 4 hours of continuous flushing to clean. The cleaning of high pressure circuits will require a minimum of 2 hours flushing. There is no specific oil flushing interval during normal test stand operations, but it should be performed under conditions listed below.

a. Following test stand installation.

b. Whenever oil is added to the system.

c. Whenever oil system plumbing modification or replacement occurs.

d. Whenever contamination is verified.

2.4.3. SETUP. The test stand setup is the same for flushing all types of oil system contamination. However, when flushing a newly installed stand, a thorough check of all facility services connections should be completed before beginning the flushing operation setup. Refer to section I, figure 1.1 for facility services requirements.

a. Set the following front panel controls in open:

(1) Ball valve (100) load valve

(2) Regulating valve (139) head flow check valve bypass

(3) Regulating valve (140) rod flow check valve bypass

(4) Ball valve (151) operate position

(5) Ball valve (153) operate position

(6) Ball valve (155) operate position

(7) Needle valve (142)

(8) Needle valve (143)

(9) Needle valve (101) head port bypass valve

(10) Needle valve (102) rod port bypass valve

b. Set the following panel controls in closed:

(1) Toggle valve (128) PT4 bleed

(2) Toggle valve (129) load valve circuit bleed

(3) Ball valve (112) valve #4 pad fill (secondary seal)

(4) Toggle valve (124) valve #2 pad drain (in sink B)

(5) Toggle valve (125) valve #1 primary seal leakage (in sink B)

(6) Ball valve (137) valve #3 primary seal

(7) Ball valve (150) operate position

(8) Ball valve (152) operate position

(9) Ball valve (154) operate position

(10) Toggle valve (126) transducer (60) bleed PT17 (HI side)

(11) Toggle valve (127) transducer (60) bleed PT18 (LO side)

(12) Ball valve (130) transducer (49) bleed

(13) Ball valve (131) transducer (43) bleed

(14) Ball valve (132) transducer (48) bleed

(15) Ball valve (133) transducer (41) bleed

(16) Ball valve (134) transducer (42) bleed

c. Set the following pressure controllers at minimum pressure, full ccw:

(1) Pressure regulator (409)

(2) Pressure regulator (410)

(3) Pressure regulator (411)

(4) Relief valve (426)

(5) Relief valve (431)

(6) Relief valve (432)

(7) Relief valve (433)

(8) Pressure regulator (434)

d. Set the following controls as indicated:

(1) Ball valve (110) transducer (40) selector, OPERATE

(2) Ball valve (111) transducer (40) selector, OPERATE

(3) Block valve (113) sink collection tank pump, OFF

e. Cap the following ports using caps from the test kit:

(1) Port PT27 (611)

(2) Port PT28 (616)

(3) Port PT6 (613)

(4) Port PT7 (612)

(5) Port PT21 (621)

f. Using hose assembly and parts from test kit, connect test stand ports PT1 and PT6.

g. Using hose assembly and parts from test kit, connect test stand ports PT3 and PT7.

h. Install tee (K-17) in port PT15.

i. Using hose assembly and parts from test kit, connect port PT11 to tee (K-17).

j. Using hose assembly and parts from test kit, connect port PT16 to tee (K-17).

2.4.4. VEN POWER UNIT AND ACTUATOR CIRCUITS FLUSHING. The flushing procedures for each circuit are listed separately, but the test stand setup (paragraph 2.4.3) and procedure herein is to save time by flushing the two circuits simultaneously.

2.4.4.1. VEN Power Unit Circuits.

a. Supply/Return and Head/Rod Circuits.

(1) Refer to Test Program Instruction (TPI) manual, section II, and complete prestart procedure and test stand startup.

(2) Press operator station (766) START pushbutton.

(3) Set selector switch (750) to fill position.

(4) Using regulator (430) and pressure indicator (664), set port PT1 pressure at 100 ±5 psig.

(5) Record start time and maintain oil circulation for 4 hours, minimum.

NOTE

Recommended sequence for flushing is to start the actuator circuit procedure (refer to paragraph 2.4.4.2) as soon as possible. This provides simultaneous circulation and a saving in total time required for flushing.

(6) Using pressure regulator (430) and indicator (664), reduce port PT1 pressure to minimum.

(7) Press operator station (766) STOP pushbutton.

b. Supply/Return and Cooler Circuits

(1) Using hose assembly and parts from test kit, connect ports PT1 and PT5.

(2) Using hose assembly and parts from test kit, connect ports PT2 and PT4.

(3) Press operator station (766) START pushbutton.

(4) Set selector switch (750) to fill position.

(5) Using regulator (430) and pressure indicator (664), set port PT1 pressure at 100 ±5 psig.

(6) Record start time and maintain oil circulation for 4 hours, minimum.

(7) Occasionally during flushing, set selector switch (750) to VENT FLOW and note oil stream thru flow indicator (452).

(8) Take oil sample from sample port as described in 2.4.4.3.

(9) Using regulator (430) and pressure indicator (664), reduce port PT1 to minimum.

(10) Press operator station (766) STOP pushbutton.

2.4.4.2. Actuator Circuits.

a. Head/Rod Main Flow Circuit.

(1) Install tee (K-17) in port PT15.

(2) Using hose assembly and parts from test kit, connect port PT11 to tee (K-17).

(3) Using hose assembly and parts from test kit, connect port PT16 to tee (K-17).

(4) Set selector switch (749) in ACTUATOR position.

(5) If test stand is not already operating, refer to Test Program Instruction (TPI) manual, section II, and complete prestart inspection and test stand startup.

(6) Press main supply pump operator station (746) START pushbutton.

(7) Using relief valve (431) and pressure regulator (434), increase reading on indicator (670) to approximately 50 psig.

(8) Set selector switch (757) to MANUAL position.

(9) Set selector switch (755) to EXTEND position.

(10) Set needle valves (101 and 102) to closed, full cw, then ccw toward open 1/4 turn.

(11) Record start time and maintain oil circulation for 3 hours, minimum.

(12) Set selector switch (755) to RETRACT position.

(13) Record start time and maintain oil flow for 3 hours, minimum.

(14) Set selector switch (755) to OFF position.

b. Head/Rod High Pressure Circuit.

(1) Install tee (K-17) in port PT27.

(2) Using hose assembly and test kit parts, connect port PT12 to tee (K-17).

(3) Using hose assembly and test kit parts, connect port PT28 to tee (K-17).

(4) Set selector switch (749) to HI PRESS position.

(5) Set relief valves (432 and 433) cw until increased pressure is felt in control knob.

(6) Record start time and maintain oil circulation for 2 hours, minimum.

(7) Set relief valves (432 and 433) to open, full ccw.

(8) Press main pump operator station (746) STOP pushbutton.

2.4.4.3. Oil Sampling Procedure.

a. Use 2 1-quart bottles for sampling, one for initial flush and rinse and one for the sample.

b. Allow a small amount of oil to flow into the sink.

c. Place bottle #1 under sample port, fill about half full.

d. Place bottle #2 under sample port and rinse sides of bottle to about half full.

e. Pour bottle #2 oil into bottle #1.

f. Fill bottle #2 at least 3/4 full from sample port.

g. Seal and label sample bottle.

SECTION III

OPERATION

3.1. GENERAL.

The test stand is designed to test VEN system accessories, also referred to herein as the unit under test (UUT). The stand systems provide the UUT with oil at required flow rates, pressures and temperatures, variable speed driving power and lubrication, controllable backpressure loading and instrumentation for measuring performance. Refer to the schematic diagrams in figures 3.1 and 3.2 while reading the following system descriptions.

3.2. OIL SYSTEM OPERATION.

The oil system consists of the reservoir, the test circuits for the UUTs and the collector tank circuit.

3.2.1. OIL RESERVOIR. The oil reservoir (500) capacity is 40 gallons and it is located in the rear center section of the test stand. Temperature switch (531), set at 105 ±5 °F, monitors reservoir oil temperature. An overtemp condition opens the switch contacts and operates control relay (822) to turn off the green temperature normal indicator (773) and light the red temp high indicator (783) on panel E.

3.2.1.1. Quantity Indicator. Oil quantity is measured by direct-reading level indicator (450) which is mounted on the side of the reservoir.

3.2.1.2. Level Switches. Level switch (449) is installed on the oil indicator (450) of the reservoir. Two level switches, LL1 and LL2, monitor oil level. When oil level is above set point of switch LL2, its contacts close and operate control relay (807). Two sets of relay contacts then operate at the same time. One set turns off the amber level low indicator (733) and the other set turns on the green level normal indicator (774). When the oil level falls below the set point of switch LL2, its contacts open and amber level low indicator (733) lights. If level falls below switch LL1, a set of relay (808) contacts then open to shut down power to the test stand. At restart, level low shutdown red indicator (784) will be lit.

3.2.1.3. Reservoir Servicing.

CAUTION

The test stand is built to use MIL-L-7808 or MIL-L-23699 lubricating oil. Ensure that oil used for servicing is the correct type.

The reservoir may be serviced manually thru top-mounted flash arrestor fill unit (559) or thru the pressure fill port (352) on the service connections panel. Oil from the pressure port passes thru ball valve (141), filter (312) and into the reservoir. If the filter is clogged, control relay (830) is actuated and its contactor lights red indicator (797) on panel E. The reservoir is drained thru ball valve (123) and drain port (353) on the service connections panel.

3.2.2. TEST CIRCUITS. The oil and instrument system connections for the UUT are located in the sink area where it is tested. Test setup equipment for the VEN actuator and position transducer is located in sink A area. The VEN power unit test setup connections are in the sink B area.

3.2.2.1. Sink A Test Circuits. Pressure for these circuits is provided by the main supply pump (341), which is driven by a 15 hp motor (702). Oil from reservoir (500) passes thru ball valve (147), strainer (301) and pressure switch (523) to the pump inlet. The pressure switch set point is 5 ±2 in mercury vacuum. If pump suction drops below the set point, the switch contacts open to actuate control relay (824) and three sets of relay contactors. One set opens to turn off green inlet pressure normal indicator (777) and the second set closes to turn on red pressure low indicator (787). The third set opens to shut down pump motor (702) power at operator station (746). Pressure taps (576 and 577) are mounted in the line each side of pump (341). Pump output feeds three test circuit pressure lines, each with separate flow and pressure ratings, which are described below.

3.2.2.1.1. Circuit 1 Pump. Circuit 1 is rated at 500 psi and 6.3 gpm. Flow passes from the pump outlet thru filter (314), overpressure regulator (422), set at 500 psig, and one-way check valve (208). The filter has an electrical clog indicator switch. If a clog occurs, the switch closes to actuate control relay (801). This

closes a relay contactor which lights red hydraulic supply filter clogged indicator (789). Flow and pressure is regulated by front panel pressure relief valve (431). Discharge flow from the three regulating units in circuit 1 is routed to the main system return line. At this point, pressure output is split to supply three test stand port, PT11, PT15 and PT16.

a. PT11 Supply. Line pressure to port PT11 is set by pressure reducing valve (435) which is controlled by pressure regulator (434). Flow then passes thru thermocouple (243) and the port outlet. Thermocouple readout is on indicators (679) channel 5. Pressure transducer (46) is accessed thru ball valve (155), read on pressure indicator (670) and calibrated thru port PT29. Transducer (46) is equipped with bleed valve (154). A bypass line between PT11 and PT16 is connected thru solenoid-operated ball valve (185) and one-way check valve (213). Another bypass line between PT11 and PT28 is connected thru solenoid-operated ball valve (184) and one-way check valve (211).

b. PT15 Supply. Flow to port PT15 is monitored by thermocouple (237), displayed on temperature indicator (679) channel 1, and flow is controlled by double solenoid valve (172). From there, flow passes thru pressure tap (575) and one-way check valve (206). Pressure in this segment is limited by relief valve (423), set at 400 psig. Finer control is provided thru a bypass valve (101). Flow then passes thru one-way check valve (206) which is paralleled by regulating valve (139) onto the port outlet. Access to transducer (44), read on pressure indicator (668), is provided by shutoff valve (151). Calibration access is port PT14 and bleed thru ball valve (150).

c. PT16 Supply. Flow to port PT16 is controlled by double solenoid valve (172). The pressure then passes thru one-way check valve (205). Pressure control is provided by a bypass line containing regulating valve (140). Flow then passes thermocouple (244) and into the port outlet. Access to transducer (45), read on pressure indicator (669), is provided by shutoff valve (155). Port PT13 is used for calibration and bleed thru ball valve (152).

3.2.2.1.2. Circuit 2. Pump circuit 2 is rated at 4800 psi and 0.5 gpm. From the pump outlet, flow passes thru filter (313) and 3-way solenoid valve (170). The filter has an electrical clog indicator switch. If a clog occurs, the switch closes and actuates control relay (872). This closes a relay contactor which lights red medium pressure filter clogged indicator (790). Line pressure in this segment is controlled by overpressure relief valve (427), set at 4800 psig. Pressure control is provided by panel-mounted relief valve (433). Regulated flow then passes thru needle valve (142) high pressure transducer (50) and port PT27 outlet. Pressure in this segment is read on pressure indicator (671). Calibration port for transducer (50) is at PT27 with needle valve (142) closed. Discharge from the pressure regulators in circuit 2 is routed to the main system return line.

3.2.2.1.3. Circuit 3. Pump circuit 3 is rated at 9400 psi and 0.8 gpm. From the pump outlet, flow passes thru filter (316) and 3-way solenoid valve (169). The filter is monitored by differential pressure switch (525), set at 30 ±5 psid. Switch contacts are wired into Safe-Pac relay (847) and control relay (800). If filter differential exceeds the pressure switch set point, switch contacts close to actuate the control relay. This closes a set of relay contacts and lights red high pressure filter clogged indicator (791). The filter drain is thru needle valve (142) to the drip pan. Line pressure for this segment is controlled by overpressure relief valve (425), set at 9400 psig. Control is provided by panel-mounted relief valve (432). Regulated flow then passes thru needle valve (143), transducer (52) and port PT28. Pressure in this segment is read on pressure indicator (672). For transducer (52) is at PT28 with needle valve (143) closed. Discharge from the pressure regulators in circuit 3 is routed to the main system return line.

3.2.2.1.4. UUT Returns. Return flow from UUTs is thru port PT12. Flow then passes thru filter (315), paralleled flowmeters (92 and 94) and thermocouple (236). The filter has an electrical clog indicator switch. If a clog occurs, the switch closes to actuate control relay (806). A set of relay contacts then close to light the red PT12 return port filter clogged indicator (799). Low-range flowmeter (92) is bypassed thru ball valve (186) at flows exceeding 2.5 gpm by an internal alarm in flow computer (683). The flowmeters and thermocouple readouts are on indicator (683). Additional flowmeter readouts are provided on indicators (874 and 875) for flowmeters (92 and 94) respectively. Flow then passes air-loaded relief valve

(421), which is controlled by air pressure regulator (411) and one-way check valve (212). It then joins the main system return line.

3.2.2.1.5. Discharge Returns. Discharge return flow from all pressure regulators is connected to a common line which joins the main system return. Discharge from bypass valves (101 and 102), transducer bleed sight glass (454) and discharge manifold (502) are routed directly back to tank to reduce backpressure.

3.2.2.1.6. Differential Pressure Circuit. Differential pressure transducer (60) is read on indicator (673). Access to the high side is thru port PT17 and thru port PT18 for the low side. Bleed valves for the high and low sides are toggle valves (126 and 127), respectively. Bleed flow is routed thru bleed indicator (454).

3.2.2.2. Sink B Test Circuits. Pressure for these circuits is provided by the fill supply pump (340) which is driven by a 2-hp motor (part of 340). VEN power unit pressure is also required in order to operate test equipment which measures UUT performance. Oil from reservoir (500) passes thru ball valve (138), strainer (300), pressure switch (522) and into the pump inlet. The pressure switch setpoint is 5 ±2 in.mercury vacuum. If pump suction drops below the set point, switch contacts open to actuate control relay (823) and three sets of relay contacts. One set opens to turn off green fill pump inlet pressure normal indicator (776) and the second set closes to turn on red pressure low indicator (786). The third set opens to shut down pump motor power at operator station (766). Pressure taps (570 and 571) are mounted each side of pump (340). Pump output then flows thru oil heater (333), filter (310), thermocouple (885) and pressure relief valve (420), set at 375 psig maximum, which is operated by remote pilot relief valve (430). The filter has an electrical clog indicator switch. If a clog occurs, the switch closes, actuating control relay (809) and closing one relay contacts to light red fill supply filter clogged indicator (792).

NOTE

Oil heater (333) is required for hot oil input in some test procedures. Heater operation is described in this section under Electrical System.

The discharge flow from regulating units (420 and 430) is routed to system return. Regulated flow then passes thru solenoid valve (161), thermocouple (245) and transducer (47) to port PT1 outlet. Thermocouple readout is on temperature indicator (678) channel 7 and pressure readout is on indicator (664). Bleeding is provided thru ball valve (136) and calibration thru PT1 with ball valve (111) in closed (calibrate) condition.

3.2.2.2.1. Oil Cooler Circuit. Hot oil discharged from UUT relief valves and bleed flow is routed through the oil cooler before being returned to the cooler circuit thru port PT5, thermocouple (233) and union orifice (578) into heat exchanger (330). The thermocouple is read on temperature indicator (678) channel 4. The orifice flow rating is 2.7 gpm at 45 psig and three additional cooler circuit input lines, described in subsequent paragraphs, are routed thru it. Heat exchanger oil-out temperature is monitored and controlled by pilot temperature controller (552), set at 130 °F. Using 20 psig air, the controller modulates coolant water flow thru air-operated control valve (181). Heat exchanger output passes thru thermocouple (232) and the cooler return port PT4. A bleed bypass line, controlled by toggle valve (128), is provided. Flow is routed thru bleed indicator (455) and into the bleed return manifold (502) which is connected to reservoir (500).

a. Load Loop Input. The load loop is a set of flow restrictors which provide an operating load on the UUT during performance testing. An instrumented line from the loop is connected to the heat exchanger input thru thermocouple (241) and flowmeter (91), both read on flow computer (683).

b. UUT Primary and Secondary Seals Input. The output from UUT primary seal is directed thru toggle valve (125) in sink B to a leakage measurement beaker or into the sink drain. The second path is thru ball valve (137) to the heat exchanger input line. The UUT secondary seal output has two paths from the power unit mount (39). One is thru the leakage measurement tube (451) and back to oil reservoir (500) thru bleed return manifold (502). The second path is thru ball valve (112) to the heat exchanger input. A bypass from this line is used to collect oil samples for analysis. Port PT26, controlled by toggle valve (126), is opened to flow thru a nozzle directed into sink B.

3.2.2.2.2. Rod and Head Port Circuit. The rod port, PT6 and head port, PT7 are the UUT output connections at opposite ends of the load loop. The load loop consists of fixed and adjustable flow restrictors connected in the circuit to provide loading on the UUT during performance testing. Controlled conditions are maintained within the loop by temperature and flow monitors, limit switches and a heat exchanger with automatic control unit.

a. Rod Port Flow. Rod port PT6 flow is thru filter (317), temperature switch (530), set at 145 ±5 °F, pressure tap (573) and oil-in temperature monitor thermocouple (234). The filter has an electric clog indicator switch. If a clog occurs, switch contacts close and actuate control relay (811). This closes a set of relay contacts which light red rod port filter clogged indicator (794). If oil-in flow exceeds the temperature switch setting, switch contacts open and actuate control relay (825) and two sets of relay contactors. One set opens to shut off green ROD PORT TEMP NORMAL indicator (778) and one set closes to light red TEMP HIGH indicator (788). Thermocouple readout is on indicator (678) channel 5. Rod flow then splits to follow two paths in the load loop. One line flows thru parallel-mounted Lee unions (555 and 558) and into the UUT cooler input circuit thru thermocouple (241) and flowmeter (91). Both readouts are on flow computer (683). The second rod flow path is thru one-way check valve (202), load control needle valve (100) and into heat exchanger (331). Load loop pressure is monitored by pressure switch (524), set at 500 ±20 psig. A bypass line around the load valve is provided thru solenoid shutoff (162), controlled by selector switch (765), which is used to turn the load valve off or on. If loading exceeds the pressure switch setting, switch contacts close to actuate control relay (827) and three sets of relay contacts. One set opens to turn off green LOAD VALVE ON indicator (775) and the ac drive (700) if they are on. The two remaining relay contactors close to actuate solenoid valve (162) into open position and to light red LOAD VALVE BYPASSED indicator (785), respectively.

b. Head Port Flow. Head port PT7 flow is thru filter (318), thermocouple (235) and pressure tap (574). the filter has an electrical clog indicator switch. If a clog occurs, switch contacts close, actuating control relay (812) and one relay contactor. The contactor closes to light red head port filter clogged indicator (795). The thermocouple readout is on temperature indicator (678) channel 6. Head

flow then splits to follow two paths in the load loop. One line flows thru parallel-mounted Lee unions (556 and 557) and into the UUT cooler input circuit thru thermocouple (241) and flowmeter (91). Both readouts are on flow computer (683). The second head flow path is thru one-way check valve (204), the load control valve circuit (as described in the previous paragraph), heat exchanger (331), flowmeter (93) and thermocouple (242). Both readouts are on flow computer (683). A bleed bypass tap is provided between the load loop and heat exchanger. Access is thru toggle valve (129) and flow is thru bleed indicator (456) and bleed return manifold (502) to the reservoir. Heat exchanger (331) oil-out temperature is monitored and controlled by pilot controller (553). Using 20 psig air, the controller modulates cooling water flow thru air-operated control valve (180) to maintain the oil-out temperature selected.

c. Power Unit Pressure Circuit. The power unit pressure circuit consists of six pressure transducer access ports, bleed valves and a bleed indicator mounted on panel C. This circuit and the associated transducers and indicators are used to monitor UUT output during performance testing. Bleed flow from all transducers is thru flow indicator (453) and bleed return manifold (502) to the reservoir.

1. Boost Pressure. Access is thru port PT23 to transducer (43) read on indicator (663). Bleed is thru ball valve (131).
2. Servo Pressure. Access is thru port PT24 to transducer (48) read on indicator (665). Bleed is thru ball valve (132).
3. Case Pressure. Access is thru port PT20 to transducer (42) read on indicator (662). Bleed is thru ball valve (134).
4. Reservoir Pressure. Access is thru port PT19 to transducer (41) read on indicator (661). Bleed is thru ball valve (133).
5. Head Pressure. Access is thru port PT22 to transducer (49) read on indicator (666). Bleed is thru ball valve (130).
6. Rod Pressure. Access is thru port PT21 to transducer (51) with readout on indicator (667).

3.2.3. MAIN SYSTEM RETURN. The main system return, combining return flow from sinks A and B test circuits, flows thru water-cooled heat exchanger (332) en route to reservoir (500). Thermocouples (239 and 238), read on temperature indicator (679), monitor oil-in and oil-out temperature, respectively. Temperature controller

(554), using 20 psig air, modulates cooling water flow control valve (182) to maintain the oil temperature selected.

3.2.4. COLLECTION TANK CIRCUIT. Drainage from test sinks A and B flows into the 5-gallon collector tank (503). It has a top-mounted, flame arrestor type vent (561) and level switch (753). The air-operated drain pump (342) is powered by 90 psig air metered thru block valve (113) which is paralleled by solenoid valve (167). Valve (113) is a manual control of tank drain and solenoid valve (167) operates at high-limit actuation also indicated by lighting red light (734). Pump output exits the test stand thru collection tank drain (352) on the service connections panel.

3.3. SHOP AIR SYSTEM OPERATION.

Shop air enters the test stand at the service connections panel thru ball valve (122). It then passes thru filters (319 and 320). Each filter is equipped with a differential pressure indicator and automatic condensate drain which empties into the drip pan. Air then passes thru 3-way solenoid valve (163) when energized, pressure switch (520) and into air tank (501). The solenoid shutoff operates automatically during test stand startup and shutdown. When the solenoid de-energizes, system pressure is vented to atmosphere thru muffler (550). The pressure switch set point is 60 ±2 psig. If pressure falls below the set point, the switch opens actuating control relay (804) and two sets of relay contacts. One set opens to turn off green shop air pressure normal indicator (771) and the second set closes to turn on red shop air pressure low indicator (781). Air tank (501) pressure is displayed on gage (70) and tank drainage into the drip pan is thru ball valve (146). The 90 to 125 psig tank pressure is reduced by three gage-equipped regulators which supply air service lines of 90, 50 and 20 psig.

3.3.1. 90 PSIG SERVICE. Air pressure regulator (401) reduces facility shop air pressure to 90 psig. Air from this service line thru ball valve (116) supplies air guns (562 and 565) and electro-pneumatic ball valves (184, 185, 186, 187 and 188). The 90 psig service line also supplies air-operated collection tank pump (342) thru manual valve (113) and paralleled by solenoid (167) controlled by high level switch in collector tank.

3.3.2. 50 PSIG SERVICE. Air pressure regulator (400) reduces facility shop air pressure to 50 psig. Air then flows thru air pressure regulator (410) and into normally-closed solenoid valve (164). When solenoid (164) is energized, flow then passes transducer (40) and provides PAD air supply thru port PT8. Transducer (40) readout is on pressure indicator (660). When de-energized, solenoid valve (164) connects port PT8 and ball valve (110) which is open (vented) during normal operation and closed to calibrate.

3.3.3. 20 PSIG SERVICE. Air pressure regulator (402) reduces facility shop air pressure to 20 psig. Air then flows to three temperature controllers (552, 553 and 554) which modulate three air-operated solenoid valves (181, 180 and 182) controlling cooling water flow thru heat exchangers (330, 331 and 332), respectively. The air motor exhausts thru a built-in muffler to atmosphere.

3.4. WATER SYSTEM OPERATION.

Facility water enters the test stand at the service connection panel bezel (355) thru ball valve (148). Inlet pressure is displayed on gage (71). Water flows thru strainer (302), the pressure gage, pressure switch (521) and thermocouple (230) and into the service lines. The pressure switch set point is 32 ±2 psig. If pressure falls below the set point, the switch contacts open, actuating control relay (805) and two sets of relay contacts. One set opens to turn off green water pressure normal indicator (772). The second set closes to turn on red water pressure low indicator (782). The water-in thermocouple readout is on temperature indicator (678) channel 1.

3.4.1. WATER SUPPLY. Three service lines supply cooling water to the three heat exchangers (330, 331 and 332). Water outflow thru air-operated solenoid valves (181, 180 and 183) is modulated to maintain selected oil temperatures by the three associated temperature controllers (552, 553 and 554), respectively.

3.4.2. WATER RETURN. Return lines from the three heat exchanger circuits feed into a single line which passes thru thermocouple (231), read on temperature indicator (678) channel 2, pressure tap (572), thru check valve (221), set to open at 8 in. water, and exits the test stand at bezel (356).

3.5. ELECTRICAL SYSTEM OPERATION.

Facility electrical power, 460 Vac, 3-phase, 60 Hz, enters the test stand thru overhead conduit which is attached at the roof panel above the electrical enclosure. Phase leads are connected to the 3-pole main circuit breaker. Power is then fed to the ac drive system drive cabinet and drive transformer, the oil heater, the main supply pump and the fill pump, which comprise the 460-volt circuit. The low side of a 240/120 Vac transformer (735) powers 5 interlocking circuits, connected by load center (722), which provide control and operating current to the remaining electrical units in the test stand.

3.5.1. 460-VOLT CIRCUIT. The components of the test stand high voltage circuit receive power from the circuit breakers and unit connector panels in the electrical enclosure.

3.5.1.1. Electrical Enclosure. The electrical enclosure is located at the right-center on the rear wall of the test stand. Access is thru a full length door, which is protected by a power shutoff switch on the latching lever. Inside are the main circuit breaker (720), the breakers for the two oil system pumps and the main power connections for the heater control panel (334). The transformer and load center for the control power circuit are also located within the enclosure. Power is carried from the test stand to the drive cabinet and drive transformer in overhead conduit.

3.5.1.2. Main Supply Pump. The main supply pump (341) is powered by 15-hp motor (702). Motor protection is provided by 100-amp circuit breaker (723). The motor and pump are started by pressing the operator station (746) ON pushbutton. Motor start contacts (709) then latch, the green indicator is lighted and the ON pushbutton is released. For shutdown, the OFF pushbutton switch is pressed. This unlatches the motor starter contacts and disconnects power to the pump motor and green indicator.

3.5.1.3. Fill Supply Pump. The fill pump is powered by a 2-hp motor which is part of the pump assembly (340). Motor protection is provided by circuit breaker (724). The unit is started by pressing operator station (766) ON pushbutton. Motor starter (710) contacts then close to maintain power to the motor and green indicator after the ON pushbutton is released. For shutdown, the operator station (766) OFF

pushbutton is pressed. This opens the motor starter (710) contacts which disconnects power to the pump motor and green indicator.

3.5.1.4. AC Drive. The ac drive (700) receives power from the test stand electrical enclosure thru overhead conduit to the drive cabinet input circuit breaker. Wiring between the drive cabinet and drive transformer is also carried in conduit. The following electrical indicator and control items are mounted on the drive cabinet door:

a. Drive motor hour meter.
b. Overspeed reset pushbutton.
c. POWER ON indicator.
d. Drive rotation FWD/REV selector switch.
e. Power circuit breaker ON/OFF switch.

NOTE

The ac drive control circuits have the following features:

- A 5-second delay relay and zero speed interlock in startup circuit. Speed potentiometer must be set on zero to enable START pushbutton.
- Cooling blower on drive motor may run up to 15 minutes after drive system shutdown.

To start ac drive, check/set drive cabinet indicators/controls, set potentiometer (767) at zero, press operator station (747) START pushbutton. Cooling blower and drive 5-second delay relay will start, drive motor contactors will close to maintain power on drive startup circuit and green START indicator when pushbutton is released. Delay relay will time out and drive rotation will begin when speed command is set on speed potentiometer (767). Drive rpm is displayed on indicator (660). To stop the drive, select zero rpm on potentiometer and press the operator station (747) STOP pushbutton.

3.5.1.5. Oil Heater. The oil heater (333) and heater control panel (334) both require 460 Vac power. The heater power panel (part of 334) is mounted in the electrical enclosure lower section. The 120 Vac power for heater controls is received from load center (722) circuit 3 thru circuit breaker (729).

3.5.2. 120-VOLT CIRCUITS. The 120-volt circuits receive power from two phases of the three-phase facility power thru circuit breaker (721) and the low side of 240/120 Vac transformer (735). Power is then passed thru a second circuit breaker (726) and connected to a six-circuit load center (722). From here the circuit provides 120-volt control and operating power to five interlocking circuits, each with individual, 15-ampere circuit breakers (727 thru 731). Load center circuit 6 is not used. Load center (722) circuits 1 thru 5 are described in the paragraphs below.

3.5.2.1 Circuit 1, Circuit Breaker (727). With power thru this breaker, it enables, activating the sound enclosure light (760) controlled by toggle switch (756), the four test stand interior lights (761 thru 764) controlled by manual switch (741), and the stand power operator station (745) thru the emergency pushbutton switches (742 thru 744).

NOTE

When any emergency pushbutton is pressed, it interrupts 120 Vac stand control power to all load center (722) circuits. When the pushbutton is released, power is restored to sound enclosure and test stand interior light circuits and the maintenance switch (740).

With the maintenance switch (740) on and the stand power ON pushbutton (745) is pressed, it lights the green indicator and starts time delay relay (828) which has three sets of contacts. One set closes to maintain power to the start circuit and green indicator thru the closed OFF contacts and open ON contacts. When the relay times out, the remaining two contactors close. One enables the remainder of load center (722) circuit 1, and one set actuates both control relay (813) and the normally-closed shop air solenoid valve (163). Control relay (813) has 5 sets of contacts. One set enables annunciator reset pushbutton switch (748). The remaining four sets each enables a load center (722) circuit (2 thru 5) immediately downstream of the respective circuit breaker (728 thru 731). When the reset pushbutton is pressed, it actuates control relays (815 and 819). Together, the two combine to operate 18 sets of relay contactors which reset the annunciator indicators on

panel E. Annunciator functions powered by circuit 1 are described under Shutdown and Safety Systems in this section.

3.5.2.2. Circuit 2, Circuit Breaker (728). A control relay (813) contactor, located downstream of circuit breaker (728) enables circuit 2. The following paragraphs describe the operation of units in this circuit.

3.5.2.2.1. Hydraulic Pump. The hydraulic pump (341), powered by a separate motor (702), is controlled by operator station (746). When the START pushbutton is pressed, motor starter contactor (709) closes and maintains power to the motor and green indicator as the pushbutton contacts are released. A permissive contactor (824), controlled by the pump inlet pressure switch (523), must be satisfied immediately after startup. The pressure switch set point is 5.0 ±2.0 in. mercury vacuum. If pump suction is not maintained above the set point, switch (523) contacts will open, actuate control relay (824) and disconnect power from the pump and green indicator. A second set of relay (824) contacts will light the pump inlet pressure low indicator (787).

3.5.2.2.2. Actuator Test Selector Switch. The test selector switch (749) has three positions, FLOW/TRANS., ACTUATOR and HI PRESS (high pressure).

3.5.2.3. Circuit 3, Circuit Breaker (729). A control relay (813) contactor, located downstream of circuit breaker (729), enables circuit 3. The following paragraphs describe the operation of units in this circuit.

3.5.2.3.1. Selector Switch (750).

3.5.2.3.2. Stopwatch Timer. The stopwatch timer (655) has a range of zero to 9 minutes 59.9 seconds. It is used in VEN power unit testing to time leakage test periods.

3.5.2.3.3. Fill Pump. The fill pump is powered by a 2-hp motor (part of pump 340) and controlled by operator station (766). When the START pushbutton is pressed, motor starter (710) contactors close and maintain power to the motor and green indicator as the pushbutton contacts are released. A permissive contactor (823),

controlled by the pump inlet pressure switch (522) must be satisfied immediately after startup. The pressure switch set point is 5.0 ±2.0 ins. water vacuum. If pump suction is not maintained above the set point, switch (522) contacts will open, actuate control relay (823) and disconnect power from the pump and green indicator. A second set of relay (823) contacts will light the pump inlet pressure low indicator (786).

3.5.2.3.4. Ventilation Blower. The panel mounted blower (703) starts operating when circuit 3 is enabled. The blower intake grill and filter are mounted on panel G. Air entering the intake is compressed and distributed thru the test stand interior electrical and electronics compartment. Discharge airflow exits the stand thru louvers in the access doors.

3.5.2.3.5. VEN Pump Servo Valve Control Unit. The VEN servo valve control unit (693) is enabled when there is power on the circuit. The UUT connection is receptacle (871) on panel (TBS).

3.5.2.3.6. Oil Heater Control. Circuit 3 provides power to the oil heater control panel (334) temperature selector module.

3.5.2.3.7. Drive Control System.

3.5.2.4. Circuit 4, Circuit Breaker (730). A control relay (813) contactor, located downstream of circuit breaker (730), enables circuit 4. The following paragraphs describe the operation of units in this circuit.

3.5.2.4.1. Power Conditioner (737). Instrument power is provided to circuit 4 components by power conditioner (737). It is powered when the circuit is enabled. It provides conditioned 120 Vac to pressure indicators (660 thru 667).

3.5.2.4.2. DC Power Supply (738). Power conditioner (737) provides conditioned 120 Vac power to dc power supply (738). It is powered when circuit 4 is enabled. It provides 15 Vdc power to pressure transducers (40 thru 43, 47 thru 49 and 51) which are paired with indicators (660 thru 667), respectively.

3.5.2.4.3. DC Power Supply (879). Power supply (879) receives 120 Vac from power conditioner (737). It provides +5, +12 and -12 Vdc power to the flow computer (683) and flow indicators (874 and 875). Flow indicator (682) and dc solid state relay (876) receive +5 Vdc from this power supply.0

3.5.2.4.4. Torque Indicator (676). the torque indicator and signal conditioner unit receive 120 Vac from power conditioner (737) and torque input from rotary torque transducer (260).

3.5.2.4.5. Temperature Indicator (678). This 10-channel unit operates on circuit 4 120 Vac. Temperature input is from 7 T-type thermocouples. Channels 8 thru 10 are spares.

3.5.2.4.6. Tachometer. The tachometer (680) operates on 120 Vac and displays ac drive (700) rpm. The drive speed signal is supplied by a magnetic pickup (a part of 260) mounted on the drive housing.

3.5.2.5. Circuit 5, Circuit Breaker (731). A control relay (813) contactor, located downstream of circuit breaker (731), enables circuit 5. The following paragraphs describe the operation of units in this circuit.

3.5.2.5.1. Power Conditioner (736). Instrument power is provided to circuit 5 components by power conditioner (736). It is powered when the circuit is enabled. It provides conditioned 120 Vac to pressure indicators (668 thru 673).

3.5.2.5.2. DC Power Supply (739). Power conditioner (736) provides conditioned 120 Vac power to dc power supply (739). It is powered when circuit 5 is enabled. It provides 15 Vdc power to transducers (44 thru 46, 50, 52 and 60) which are paired with indicators (668 thru 673), respectively.

3.5.2.5.3. Flow Indicator (682). Circuit 5 provides 120 Vac to flow indicator (682) and its two supporting units, dc power supply (878) and solid state relay (SSR) (876). Flow indicator terminal C receives 5 Vdc operating power form dc power

supply (879) to actuate SSR (876). The SSR uses circuit 5 120 Vdc to power solenoid valve (165). DC power supply (878) provides 12 Vdc to flow indicator terminal board D.

3.5.2.5.4. Torque Indicator (677). The torque indicator and signal conditioner unit receives 120 Vac from power conditioner (736) and torque signal from reaction torque transducer (261).

3.5.2.5.5. Temperature Indicator (679). This 10-channel unit operates on circuit 5 120 Vac. Temperature input is from 4 T-type thermocouples. Channels 5 thru 10 are spares.

3.5.2.5.6. Load Brake Control (690). The load brake control is powered by circuit 5 120 Vac. It supplies 28 Vdc thru a potentiometer to operate the magnetic load brake (691).

3.5.2.5.7. DC Power Supply (656). This power supply converts circuit 5 120 Vac to 90 Vdc. When toggle switch (770) is set to LOCK position, 120 Vac is connected to the power supply and the 90 Vdc output is connected to the electric lock brake (657).

3.5.3. INSTRUMENTATION CIRCUIT. There are five direct reading, analog gages on the test stand which are not a part of the electronic instrumentation system. These are the shop air and water supply gages (70 and 71) and the three gage-equipped air pressure regulators (400 thru 402). Except for these, the indicators and instrumental controls are digital units operated by 120 Vac thru two power conditioners (736 and 737). The power conditioners provide surge protection, noise suppression and voltage regulation. Seven power supply units provide dc power for the transducers, shunt calibration, actuator cycling control circuit, flow computer system and brake controls for the torque test equipment. The dc power supply item numbers and power ratings are as follows:

a. Item (656), 90 Vdc.
b. Item (part of 699), 5, 12, and -12 Vdc.
c. Item (701), 5,12,and -12 Vdc.
d. Item (738), 15 Vdc.

e. Item (739), 15 Vdc.

f. Item (879), 5,12 and -12 Vdc.

g. Item (878), 12 Vdc.

3.5.3.1. Digital Pressure Indicators. There are 14 digital pressure indicators paired with 14 pressure transducers. The pressure transducer layout is shown in table 3.1.

Table 3.1. Pressure Transducer Layout

Transducer	Range	Bleed Valve	Calibration Port	Indicator
40	0 - 100 psig	110	PT8	660
41	0 - 100 psig	133	PT19	661
42	0 - 100 psig	134	PT20	662
43	0 - 200 psig	131	PT23	663
44	0 - 500 psig	150	PT14	668
45	0 - 500 psig	152	PT13	669
46	0 - 500 psig	154	PT29	670
47	0 - 500 psig	136	PT1	664
48	0 - 1000 psig	132	PT24	665
49	0 - 1000 psig	130	PT22	666
50	0 - 5000 psig	--	PT27	671
51	0 - 7500 psig	--	PT21	667
52	0 - 10,000 psig	--	PT28	672
60 Hi	0 -15 psid	126	PT17	673
60 Lo	0 -15 psid	127	PT18	673

3.5.3.2. Transducer Shunt Calibration System. The shunt calibration selector is a two-deck selector switch (751). The selector and channel assignment chart are located on panel F.

3.5.3.3. Torque Indicators. Torque indicator and signal conditioner (677) receives raw data from reaction torque transducer (261), which is mounted on the actuator and transmitter test fixture (35). Torque indicator (676) receives raw data input from rotary torque transducer (260), which is mounted between the ac drive (700) and VEN power unit mounting pad (39).

3.5.3.4. Temperature Indicators. Temperature indicators (678 and 679) are identical ten-channel, digital indicators. A chart, listing the associated thermocouple and function for each channel, is mounted beside the indicators.

3.5.3.5. Tachometer. The tachometer (680) receives raw data from a magnetic pickup (part of 260) mounted in the drive train. The digital display indicates drive speed from zero to 9999 rpm.

3.5.3.6. Flow Computers. Two flow computer systems (682 and 683) are used to measure and display flow rates. Oil temperature and flowmeter turbine frequency are fed into the flow computer unit thru signal conditioners. Flow is then calculated, based on the temperature and the flow equation of the individual flowmeter involved. Each parameter used in the calculation may be called up on the flow computer display. The calculated flow rate is also displayed on the assigned channel of the flow computer and on the dedicated indicator for that flow channel. The flow computer systems layout is shown in table 3.2.

Table 3.2. Flow Computer Systems Layout

Channel	Flowmeter	Thermo-couple	Signal Conditioners	Digital Display	Function Measured
15	90	240	694	683	Reservoir relief flow
18	91	241	695	683	Circ./bleed flow
24	93	242	696	683	Load flow
39	95	240	711	683	VEN subassembly flow impending indicator test

Table 3.2. Flow Computer Systems Layout - Continued

Channel	Flowmeter	Thermo-couple	Signal Conditioners	Digital Display	Function Measured
21	92	236	697	683/684	VEN sink A return flow
27	94	236	698	683/685	VEN sink A return

3.5.3.7. Stopwatch Timers. Two stopwatch timers are provided for measuring UUT performance. One (654) is located on panel G and one (655) on panel D.

3.5.3.8. VEN Power Unit Servo Control. The power unit servo valve control (693) provides electrical operating control signals to the UUT during testing. It includes a digital ammeter which displays power applied to the UUT.

3.5.3.9. Actuator Cycling Control Circuit. The cycling control circuit consists of a control unit (699) and seven test operating components. These components include a down-counter (650), two timers (651 and 652), a position indicator display (653), cycle interrupt switch (719) and two selector switches which control rod/head pressure (755) and cycle mode (757). Component functions are described in the following paragraphs.

a. Down Counter (650). The mechanical display is set to select the number of cycles to be performed. As cycles are completed, the electrical display indicates the number of cycles remaining.

b. Extend Timer (651). Displays time elapsed during extend cycle. In AUTO mode, resets and starts timing at extend relay (821) actuation. Stops time when UUT reaches HIGH condition set on position transducer indicator (653) and de-energizes the relay.

c. Retract Timer (652). Displays time elapsed during retract cycle. In AUTO mode, resets and starts timing at retract relay (820) actuation. Stops time when UUT reaches LOW position set on position transducer indicator (653) and de-energizes relay.

d. Position Transducer Indicator (653). The indicator lighted display shows LOW, PASS and HIGH. The upper and lower extension limits for the UUT are selectable thru thumbwheel switches.

e. Pushbutton Switch (719). This switch, the CYCLE INTERRUPT, is used during automatic operation. It stops UUT cycling and resets the mode select switch (757) to OFF.

f. Selector Switch (755). Three positions, RETRACT, OFF and EXTEND, are used as head or rod pressure selector. When cycle mode switch (757) is in MANUAL, the RETRACT position energizes relay (820) and EXTEND energizes relay (821).

g. Selector Switch (757). Three positions, MANUAL, OFF and AUTO, are used for actuator mode selection. AUTO position is momentary only, used to start UUT cycling, and switch returns to OFF when released. Pressure selector switch (755) is enabled with MANUAL position selected and disabled with OFF selection. Both OFF and MANUAL are maintained positions on switch (757). A step-by-step description of cycling operations is presented in the following paragraph.

3.5.3.9.1. Cycling Operation. During automatic cycling, when the UUT reaches the LOW position set on the transducer indicator (653) the circuit is tripped to energize the extend relay (821). Extension will start and continue until HIGH position set on the indicator is satisfied. As full HIGH position is reached, the retract relay (820) is tripped and retraction will start and continue until low condition is satisfied.

a. Initial Conditions. For this example, set cycling controls as follows:
   (1) Start cycling in PASS condition.
   (2) Select AUTO position on mode selector switch (757) to start circuit operating.

b. Cycling circuit will operate as follows:
   (1) Retract relay (820) is energized, retract timer (652) is reset and starts timing.
   (2) UUT reaches low limit, relay (820) is de-energized, retract timer stops.
   (3) Dwell time, approximately 1 second (adjustable).

(4) Extend relay (821) is energized, extend timer (651) is reset and starts timing.

(5) UUT reaches high limit, relay (821) is de-energized, extend timer stops.

(6) Dwell time, same as step (3).

(7) Operation begins again at step (1) until selected number of cycles are completed.

NOTE

Cycle counter (650) decreases by 1 cycle as each satisfied low limit is reached.

b. Annunciator Indicators Circuit:

(1) Press RESET pushbutton (748).

(2) Green indicators (771 thru 774 and 776 thru 778)) should now be on and in agreement with system status shown in table 2.2.

(3) If any indicator disagrees with system status, determine the cause and make correction before proceeding.

NOTE

Annunciator indicators are press-to-test units. When appropriate, test indicator to ensure fault indication is not the result of a burned-out bulb.

Table 2.2. Annunciator Indicators Startup Condition

Item No.	Condition	System Status
771//781	ON/OFF	Shop air pressure normal/low
772//782	ON/OFF	Water supply pressure normal/low
777/787	ON/OFF	Main pump inlet pressure normal/low
776/786	ON/OFF	Fill supply pump inlet pressure normal/low
773/783	ON/OFF	Reservoir temperature normal/high
778/788	ON/OFF	Pump rod port temperature normal/high
774/733	ON/OFF	Reservoir oil level normal/low
784	OFF	Reservoir level shutdown
779/780	OFF/OFF	Auxiliary

c. Oil Pressure Circuit:

(1) Press pump control station (766) START pushbutton, check green light on.

(2) Check annunciator panel indicators (776 and 786) ON and OFF, respectively.

(3) Press pump control station (746) START pushbutton, check green light on.

(4) Check annunciator panel indicators (777 and 787) ON and OFF, respectively.

(5) Press control station (746 and 766) STOP pushbutton.

SECTION IV

CALIBRATION

4.1. GENERAL.

This section contains a breakdown of calibration requirements and instructions for calibrating test stand primary instruments and systems.

4.1.1. SYSTEM CALIBRATION. System calibration shall include as much of the system as possible, from the sensor detecting the measured input to the meter display indicating the results. All such calibration is performed in the test stand. Table 4.1 lists test stand system accuracy requirements.

4.1.2. PRIMARY INSTRUMENTATION. Primary instrumentation is that provided for the measurement of UUT parameters. It shall be calibrated as a discrete instrument or a complete system. Unless otherwise specified, the unit is calibrated in the test stand.

4.1.3. SECONDARY INSTRUMENTATION. These instruments monitor and measure the pressures, quantities and quality of air and fluids supplied for the operation of the test stand. Secondary system or instrument calibration is not required.

Table 4.1. System Accuracy Requirements

Parameter	Control Range	Accuracy
	VEN Power Unit	
Oil flow	0 - 10 gpm	±1% rdg
Oil pressure (pump)	0 - 9400 psig	±1% fs
Oil temperature	70 - 230 °F	±2 °F
RPM	0 - 7917 rpm	±200 rpm
	0 - 1583 rpm	±20 rpm
Torque	0 - 170 lb. in.	±1% fs

Table 4.1. System Accuracy Requirements - Continued

Parameter	Control Range	Accuracy
	VEN Actuator	
Hydraulic pressure	0 - 50 psig	±2 psig
Hydraulic pressure	50 - 9100 psig	±1% rdg or ±1 psig whichever is greater
Linear displacement	0 - 5.290 in.	±0.001 in.
Time	0 - 9.9 min. 59.9 sec.	±0.5 sec.
Temperature	90 ±20 °F	±2 °F
Leakage flow	--	±2% rdg.
	VEN Position Transmitter	
Hydraulic leakage	--	±2% rdg
Hydraulic pressure	--	±1% rdg or ±1 psig whichever is greater
Temperature	90 ±20 °F	±2 °F
Force	0 - 25 lb.	±2 lb.
Linear displacement (stroke)	--	±0.005 in.

4.2. CALIBRATION.

Table 4.2 lists the instruments requiring calibration as well as the associated parts list item number, the accuracy and frequency of calibration, control range, and a calibration reference paragraph.

4.3. FREQUENCY OF CALIBRATION.

Calibration should be performed at a frequency that will assure a high level of performance by the test stand. Table 4.2 lists a suggested calibration interval for each instrument. Actual usage may require modification of the schedule.

4.4. ACCURACY.

System and instrument accuracy shall meet certain criteria. Table 4.2 lists the requirements for the primary instruments and systems.

4.5. EQUIPMENT REQUIRED.

The calibration equipment selected in table 4.3, or equivalent test equipment, is capable of meeting critical measurements of the subject instrument within the accuracy values established. All calibration equipment must be traceable to the National Bureau of Standards.

Table 4.2. Calibration Data

Item No.	Instrument/Range	Accuracy	Frequency	Paragraph Reference
230	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
231	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
232	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
233	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
234	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
235	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
236	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
237	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
238	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
239	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
240	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
241	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
242	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
243	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
244	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
245	Thermocouple -300 to +700 °F	±1.5 °F	6 months	4.6.2
678	Temperature Indicator	±1 °F	6 months	4.6.3
679	Temperature Indicator	±1 °F	6 months	4.6.3
--	Pressure Loop 0 - 100 psig (40) Pressure Transducer (660) Digital Indicator	±0.4% fs	6 months	4.6.4
--	Pressure Loop 0 - 100 psig (41) Pressure Transducer (661) Digital Indicator	±0.4% fs	6 months	4.6.4

Table 4.2. Calibration Data - Continued

Item No.	Instrument/Range	Accuracy	Frequency	Paragraph Reference
--	Pressure Loop 0 - 100 psig (42) Pressure Transducer (662) Digital Indicator	±0.4% fs	6 months	4.6.4
--	Pressure Loop 0 - 200 psig (43) Pressure Transducer (663) Digital Indicator	±0.4% fs	6 months	4.6.4
--	Pressure Loop 0 - 500 psig (44) Pressure Transducer (668) Digital Indicator	±0.4% fs	6 months	4.6.4
--	Pressure Loop 0 - 500 psig (45) Pressure Transducer (669) Digital Indicator	±0.4% fs	6 months	4.6.4
--	Pressure Loop 0 - 500 psig (46) Pressure Transducer (670) Digital Indicator	±0.4% fs	6 months	4.6.4
--	Pressure Loop 0 - 500 psig (47) Pressure Transducer (664) Digital Indicator	±0.4% fs	6 months	4.6.4
--	Pressure Loop 0 - 1000 psig (48) Pressure Transducer (665) Digital Indicator	±0.4% fs	6 months	4.6.4
--	Pressure Loop 0 - 1000 psig (49) Pressure Transducer (666) Digital Indicator	±0.4% fs	6 months	4.6.4
--	Pressure Loop 0 - 5000 psig (50) Pressure Transducer (671) Digital Indicator	±0.4% fs	6 months	4.6.4
--	Pressure Loop 0 - 7500 psig (51) Pressure Transducer (667) Digital Indicator	±0.4% fs	6 months	4.6.4

Table 4.2. Calibration Data - Continued

Item No.	Instrument/Range	Accuracy	Frequency	Paragraph Reference
--	Pressure Loop 0 - 10,000 psig (52) Pressure Transducer (672) Digital Indicator	±0.4% fs	6 months	4.6.4
--	Pressure Loop 0 - 15 psid (60) Pressure Transducer (673) Digital Indicator			
--	Speed Sensor Loop 0 - 8000 rpm Part of Load Cell (260) magnetic pickup (680) Tachometer	±0.025%	6 months	4.6.5
90	Flowmeter, Turbine 0.06 - 3.0 gpm	±0.5% fs	12 months	4.6.6
91	Flowmeter, Turbine 0.06 - 3.0 gpm	±0.5% fs	12 months	4.6.6
92	Flowmeter, Turbine 0.06 - 3.0 gpm	±0.5% fs	12 months	4.6.6
93	Flowmeter, Turbine 0.2 - 10 gpm	±0.5% fs	12 months	4.6.6
94	Flowmeter, Turbine 0.2 - 10 gpm	±0.5% fs	12 months	4.6.6
95	Flowmeter, Turbine 0.008 - 0.08 gpm	±0.5% fs	12 months	4.6.6
--	Flow Indication Loop 0.06 - 3.0 gpm (90) Flowmeter, Turbine (683) Digital Indicator	±1% rdg	12 months	4.6.7
--	Flow Indication Loop 0.06 - 3.0 gpm (91) Flowmeter, Turbine (683) Digital Indicator	±1% rdg	12 months	4.6.7

Table 4.2. Calibration Data - Continued

Item No.	Instrument/Range	Accuracy	Frequency	Paragraph Reference
--	Flow Indication Loop 0.06 - 3.0 gpm (92) Flowmeter, Turbine (683) Digital Indicator (684) Digital Indicator	±1% rdg	12 months	4.6.7
--	Flow Indication Loop 0.20 - 10 gpm (93) Flowmeter, Turbine (683) Digital Indicator	±1% rdg	12 months	4.6.7
--	Flow Indication Loop 0.20 - 10 gpm (94) Flowmeter, Turbine (683) Digital Indicator (875) Digital Indicator	±1% rdg	12 months	4.6.7
--	Flow Indication Loop 0.008 - 0.08 gpm (95) Flowmeter, Turbine (683) Digital Indicator	±1% rdg	12 months	4.6.7
--	Torque Indication Loop 261 Torque Transducer (Reaction) 677 Torque Indicator	±1% fs	12 months	4.6.10
--	Torque Indication Loop 260 Torque Transducer (Rotary) 676 Torque Indicator	±1% fs	12 months	4.6.11
693	Ammeter (part of Servo Controller)	2%	12 months	4.6.8
--	Force Indication Loop Test Kit item Load Cell (987E421-46) 686 Torque Indicator	±1 lb	12 months	4.6.12
653	Position indicator	±0.005 in.	12 months	4.6.9

Table 4.3. Test Equipment

Model No.	Nomenclature	Accuracy	Use and Application
3325A	Hewlett-Packard frequency generator	±0.03%	Flowmeter and speed indication.
C-65-8	WAHL thermocouple calibrator -337 to +752 °F	±1 °F	Thermocouples and temperature indicator.
10-10625	Mansfield and Green deadweight tester	±0.05%	Pressure loop.
913AC	Rosemount calibration bath	N/A	Thermocouples.
77	Princo thermometer set	±0.2 °F	Thermocouples.
8842A	Fluke Digital Multimeter	±0.5%	Ammeter.

4.6. PROCEDURE.

The following shall apply in the calibration process.

WARNING

Ensure that system pressure and electrical power to affected circuits are shut off prior to disconnecting components for calibration.

WARNING

Lubricating Oil MIL-L-23699 or MIL-L-7808

- If oil is decomposed by heating, toxic gases are released.
- Prolonged contact with liquid or mist can cause dermatitis and irritation.
- Wash contacted area with soap and water. If solution contacts eyes, flush eyes with water immediately. Remove saturated clothing.
- If oil is swallowed, do not try to vomit. Get immediate medical attention.
- When handling liquid, wear rubber gloves. If prolonged contact with mist is likely, wear approved respirator.

CAUTION

Ensure all test equipment used in the following procedures is within calibration dates.

4.6.1. RECORDS. Record all input data check points such as steps, temperatures, pressures, frequencies and voltages. Record all output data as displayed.

4.6.2. THERMOCOUPLES (230 THRU 245). The thermocouples are calibrated to the accuracy and at the frequency specified in table 4.2. The calibration equipment is listed in table 4.3. Calibrate each thermocouple as follows:

a. Use the following test equipment:
   (1) Thermocouple calibrator WAHL C-65-8.
   (2) Calibration bath Rosemount 913AC.
   (3) Thermometer set Princo 77.
b. Remove thermocouple from test stand.
c. Connect thermocouple to calibrator.
d. Immerse thermocouple and thermometer into calibration bath.
e. Take 8 readings between 0 and 300 °F.
f. Record and compare readings between the calibrator and thermometer. Readings should agree within ±1.5 °F.
g. Replace thermocouple in test stand.

4.6.3. TEMPERATURE INDICATION LOOP. The temperature indication loop is calibrated to the accuracy and at the frequency specified in table 4.2. The calibration test equipment is listed in table 4.3. The calibration procedures are to be performed with the test stand power on.

a. The temperature indication loop consists of a temperature indicator with 10 input selections and a thermocouple input.
b. Test equipment required is a thermocouple simulator WAHL C-65-8.
c. Turn test stand power on, allow 60-minute warmup.
d. Locate temperature indicator (678) and thermocouple connector panel.
e. Connect thermocouple simulator to input channel 10 of temperature indicator.
f. Select channel 10 on temperature indicator.
g. Set thermocouple simulator to input 0 °F.

CAUTION

Only adjust zero and span pots. Do not touch temperature compensation R-111 pot.

h. Adjust the zero control R-115 on the temperature indicator. To expose the zero and span controls, release the thumb-locking screw and slide the chassis out until you can reach the calibration pots.
i. Set input at +250 °F and adjust span control R-116.
k. Repeat steps g thru i until readings are correct.
l. Set input at five test temperatures between 40 and 200 °F approximately 20% apart. Record results. Readings should agree with ±1 °F.
m. Remove test equipment and return to normal configuration.
n. Repeat steps c to m for indication loop (679).

4.6.4. PRESSURE INDICATION LOOP. The pressure indication loop is calibrated to the accuracy and at the frequency specified in table 4.2. The calibration test equipment is listed in table 4.3. The calibration procedures are to be performed with the test stand power on.

a. Pressure indication loop consists of a pressure transducer and a digital panel meter.
b. Associated components are shown in table 4.4.

Table 4.4. Associated Pressure Loop Components

Transducer	Range	Calibration Port	Bleed Valve	Digital Indicator
40	0 - 100 psig	PT8 (air)	110	660
41	0 - 100 psig	PT19	133	661
42	0 - 100 psig	PT20	134	662
43	0 - 200 psig	PT23	131	663
44	0 - 500 psig	PT14	150	668
45	0 - 500 psig	PT13	152	669
46	0 - 500 psig	PT29	154	670
47	0 - 500 psig	PT1	136	664

Table 4.4. Associated Pressure Loop Components - Continued

Transducer	Range	Calibration Port	Bleed Valve	Digital Indicator
48	0 - 1000 psig	PT24	132	665
49	0 - 1000 psig	PT22	130	666
50	0 - 5000 psig	PT27		671
51	0 - 7500 psig	PT21		667
52	0 - 10000 psig	PT28		672
60 (Hi)	0 - 15 psid	PT17	126	673
60 (Lo)	0 - 15 psid	PT18	127	673

c. Turn test stand power on, allow 30-minute warmup.

d. Test equipment required is a deadweight tester Mansfield and Green 10-10525.

e. Locate transducer calibration port and digital indicator for psig transducers (40 thru 52).

(1) Hook up dead weight tester to one of the above listed channels.

(2) Reduce the pressure to minimum (vented) and adjust the offset value in the digital indicator.

NOTE

Adjustment of the offset value on the digital indicator is accomplished by setting program code to 28 and stepping to OFFSET prompt. A new value for offset value can be determined by the following formula:

present offset value + current display pressure value

For more detailed information on programing the digital indicator refer to the manufacturer's manual.

(3) Increase the pressure on the deadweight tester to the maximum of the transducer involved and adjust the scale value in the digital indicator.

NOTE

Adjustment of the scaling value is accomplished by setting program code to 28 and stepping to SCALE prompt. A new value for the scale value can be determined by the following formula:

$$\frac{\text{present scale value X correct pressure value}}{\text{current display pressure value}}$$

For more detailed information on programing the digital indicator refer to the manufacturer's manual.

(4) Repeat steps (2) and (3) until readings repeat.

(5) Select 5 pressure values approximately distributed at 20% intervals throughout the range of the transducer.

(6) Carefully check each value in an increasing direction and then in a decreasing direction and record results.

(7) Compare all readings with table 4.2 for a pass or fail condition.

(8) Repeat procedure for each of the above transducers.

(9) If offset or scale value adjustment on digital indicators is required, refer to (a) or (b) below.

(a) Adjustment of the offset value on all the digital indicators is accomplished by setting program code to 28 and stepping to OFFSE prompt.

(b) Adjustment of the scaling value is accomplished by setting program code to 28 and stepping to SCALE prompt.

g. Remove test equipment and return stand to normal configuration.

4.6.5. SPEED INDICATION LOOP (680). The speed indication loop is calibrated to the accuracy and at the frequency specified in table 4.2. The calibration test

equipment is listed in table 4.3. The calibration procedures are to be performed with the test stand power on.

a. The speed indication loop consists of a 60-tooth gear, magnetic pickup and a tachometer/frequency indicator.
b. Test equipment required is a frequency generator Hewlett-Packard 3325A.
c. Disconnect magnetic pickup and connect the frequency generator to input the tachometer.
d. Turn test stand power on, allow 30-minute warmup.
e. Set frequency generator at 5,000 Hz. Indicated rpm should be 5,000 ±3 rpm.
f. Set 5 other frequencies (1000, 3000, 4500, 6000 and 8000) and record resulting speeds on a calibration sheet.
g. Indicated rpm at each test should be within ±3 rpm.
h. Remove test equipment and restore stand to normal configuration.

4.6.6. TURBINE FLOWMETERS (90 - 95). The turbine flowmeters should be flowed and the data checked with original data at the frequency and to the accuracy listed in table 4.2. If the test flow data falls outside the limits specified in table 4.2, or if the flowmeters are replaced for any other reason, new or corrected flow data should be installed in the flow computer unit (683) in accordance with appendix A.

4.6.7. FLOW INDICATION LOOP. The flow indication loop should be checked at a frequency and to accuracy limits listed in table 4.2. If the test flow readings fall outside the limits specified in table 4-2, the flow indication loop calibration test should be accomplished. The test should also be run if any component is replaced for any other reason and new or corrected flow data are installed in the flow computer unit (683). The calibration test equipment is listed in table 4.3. The calibration procedures are to be performed with the test stand power on. Flow indication loop component pairings are shown in table 4.5.

Table 4.5. Flow Indication Loop Components

Flowmeter	Channel No.	Thermocouple	Channel No.
		Flow Computer 683	
90	15	240	01
91	18	241	02
92	21	236	03
93	24	242	04
94	27	236	03
95	39	240	01
90 and 95	40	240	01

a. Perform flow loop indication test as follows:
   (1) Beginning with flowmeter (90) in table 4.5, remove the wires from the terminals indicated and connect the test cable.
   (2) Replace thermocouple that is associated with the flowmeter with test cable and connect to thermocouple test set as indicated in figure 4.1.
   (3) Locate the latest flowmeter calibration data sheet.
   (4) Set the temperature calibrator to the temperature listed in the flowmeter data sheet.
   (5) Verify the temperature by selecting the proper flow computer channel indicated in column 4 of table 4.5.
   (6) Select 5 or more frequency values evenly spaced from the flowmeter data sheet.
   (7) Select the proper flowmeter channel, read and record the flow.
   (8) Compare test results with the flowmeter data sheets for a pass or fail condition.
b. Repeat the above procedure for each of the flow channels indicated in table 4.5.
c. Remove test equipment and restore stand to normal configuration.

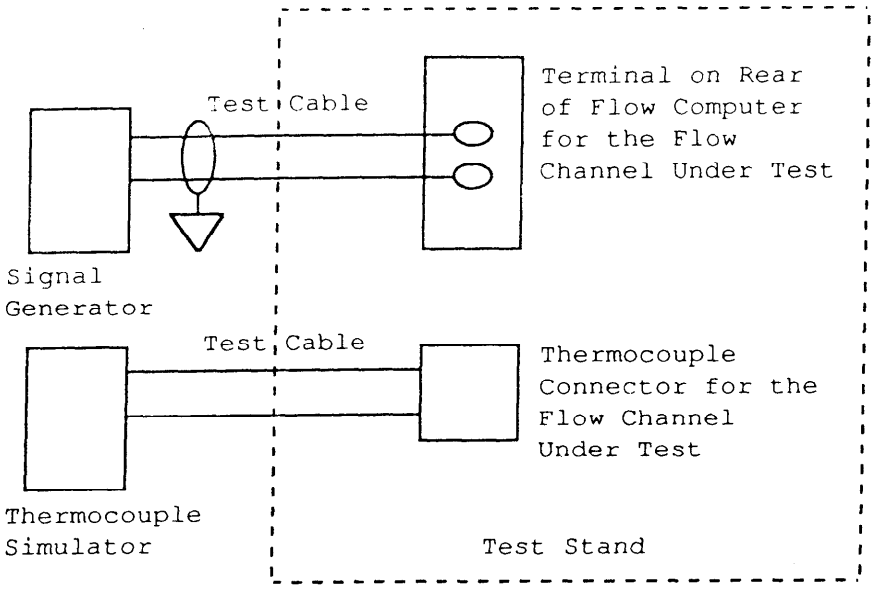

Figure 4.1. Flow Indication Loop Calibration Test Setup

4.6.8. AMMETER. The ammeter (part of item 693) is calibrated to the accuracy and at the frequency specified in table 4.2. The calibration test equipment is listed in table 4.3. The calibration procedures are to be performed with the test stand power on.

a. The ammeter displays the power being applied thru the VEN pump servo valve control to the UUT.
b. Test equipment required, Fluke 8842A Digital Multimeter.
c. Connect an approximately 20 ohm, 1 watt min., load across pins 1 and 4 of connector (681) located in the Power Unit test sink, with the calibration multimeter connected in series with one of the leads.
d. Turn on test stand power and allow a 30-minute warmup.
e. On the face of the servo controller (693), select EACH and POS.
f. Using the current control on the servo controller, set 4 current values from 0 to 120 ma. and record both the ammeter and the calibration ammeter indication at each point.
g. Repeat step f with the polarity selector set to NEG.
h. Compare the recorded data with the required accuracy listed in table 4.2.
i. Disconnect test equipment and restore the test stand to the normal operating configuration.

4.6.9. POSITION INDICATOR. The linear position indicator (653) displays UUT stroke measurement sensed by the position transducer. The transducer is mounted on the actuator and transducer test fixture (K-35). The indicator is calibrated to the accuracy and at the frequency specified in table 4.2. The calibration test equipment is listed in table 4.3. The calibration procedures are to be performed with the test stand power on.

a. Test equipment required is 1 set calibrated Jo blocks.
b. Turn test stand power on, allow 15 minute warmup.
c. Disconnect the UUT, if installed, and slave cylinder so that the slide assembly attached to the position transmitter moves freely.
d. Move the slide assembly to the left until contact is made with the end stop.
e. While holding the slide assembly against the left end stop, momentarily depress the RESET switch, located on the face of the position indicator. This action establishes the end stop as the zero point. The position indicator should now display a zero value.
f. Insert Jo blocks in one inch increments, between the end stop and the slide assembly, and record the displayed value on the position indicator. Repeat this procedure until 8 values from 0 to 7 inches have been recorded. Compare the recorded values and compare to the accuracy requirement listed in table 4.2.
g. Remove equipment and restore the test stand to its normal operating condition.

4.6.10. TORQUE INDICATOR. Torque indicator (677) displays the torque exerted on the torque table by the synchronous output of the Ven Actuator (UUT) under test. The indicator is calibrated to the accuracy and at the frequency specified in table 4.2. Dead weights are required. The calibration procedures are performed with test stand power on and the Drive System (700) off.

a. Turn on test stand power and allow a 30-minute warmup period.
b. The tare controls on the face of the indicator are to be in an off state.
c. With no load applied, observe the indicated value, it should be 0 ±1 count. Adjust the zero controls on the face of the indicator to achieve the desired value.
d. Note that there is a hole in both ends of the 10-inch bar mounted on the rear of Load Fixture (261) and thru the fixture plate immediately below. Attach a

string from the hole in the bar thru the hole in the plate. Attach a 2-pound weight to the bottom of the string, in a manner which allows it to be freely suspended. Observe the indicated value, it should be 10 in. lb. Adjust the span controls located on the face of the indicator to achieve the desired value.

e. Attach a 1-pound weight to check mid-scale valve, it should be 5 in. lb.

f. Repeat steps c and e until both desired values are displayed without further adjustment.

4.6.11. TORQUE INDICATOR. Torque indicator (676) displays the torque required to drive the Ven Power Unit (UUT) under test by the Drive Motor System (700) sensed by torque transducer (260). The indicator is calibrated to the accuracy and the frequency specified in table 4.2. No external calibration equipment is required. The calibration procedures are performed with test stand power on the Drive System (700) off.

a. Turn on test stand power and allow a 30-minute warmup period.

b. The tare controls on the face of the indicator are to be in an off state.

c. Observe the indicated value, it should be 0 ±1 count. Adjust the zero controls on the face of the indicator to achieve the desired value.

d. Depress the +cal control on the face of the indicator and observe the indicated value. Use the manufacturer's calibration data located in the Vendor Manual to determine the correct display value. Adjust the span controls located on the face of the indicator to achieve the desired value.

e. Repeat steps c and d until both desired values are displayed without further adjustment.

4.6.12. FORCE INDICATION LOOP. Force indicator (686) displays the force sensed by load cell (987E421-46) exerted during extending or retracting the transmitter during UUT testing. The force indication loop is calibrated to the accuracy and the frequency specified in table 4.2. Dead weights are required. The calibration procedures are performed with the test stand power on.

a. Turn on test stand power and allow a 30-minute warmup period.

b. The tare controls on the face of the indicator are to be in an off state.

c. Observe the indicated value, it should be 0 ±1 count. Adjust the zero controls on the face of the indicator to achieve the desired value.

d. Set the load cell on the countertop and apply a load of 50 pounds. Observe the indicated valve, it should be 50 pounds. Adjust the span controls located on the face of the indicator to achieve the desired valve.

e. Remove weight to recheck/readjust zero.

f. Repeat steps d and e until required results achieved.

g. Apply 3 intermediate loads approximately 10, 20 and 30 pounds to confirm linearity.